Response to Annual Technical Progress Review Report of the np->dγ Experiment of the Department of Energy of Office of Nuclear Physics

The NPDGamma collaboration would like to thank the DOE and members of the annual technical review panel for their careful consideration of our technical progress on the construction of the $n+p \rightarrow d+\gamma$ experiment. The panel's report makes many insightful comments and helpful suggestions for bringing the project to successful completion. The collaboration appreciates the panel's work. In most cases we have already taken actions to implement the panel's recommendations. This letter summarizes our response to the primary findings of the review panel and describes actions we have taken to the panel's suggestions. We respond first to the DOE recommendations and then to other issues in later sections of the review report. We end with discussion of the liquid hydrogen target effort.

DOE recommendations and responses

■ "The collaboration should make the best achievable measurement at LANSCE to learn as much as possible about the apparatus and to obtain a first physics result"

The NPDGamma collaboration is strongly committed to complete the construction of the experiment as soon as possible and run the experiment on flight path 12 for the sensitivity of $5\text{x}10^{-8}$ on the gamma asymmetry A_γ. This will be the best measurement ever on A_γ. With the neutron flux of flight path 12 this sensitivity should take approximately 1000 h. The collaboration will propose to move the experiment to FNPB at SNS where the original goal sensitivity of $5\text{x}10^{-9}$ will be achieved as soon as there is a call for proposals or letter of intent.

■ "Develop a detailed run plan for commissioning and experimental operations, and a clear strategy for carrying out the analysis of the data"

A detailed run plan for the 2005 beam cycle has been formulated and approved at the last collaboration meeting, and is being followed. It was described in our earlier response to DOE (enclosed, Appendix A). Analysis of the commissioning run results has and will exercise well our analysis procedures. We have appointed an analysis coordinator.

■ "A run coordinator should be identified for the upcoming run"

This has been done: For the 2005 beam cycle David Bowman of Los Alamos is the run coordinator and Bill Hersman of New Hampshire is the shift coordinator. See Appendix A.

■ "An analysis coordinator should be appointed in the near future"

The Executive Committee has asked Greg Mitchell to serve as analysis coordinator and he has agreed to do so. Greg functioned as the *de facto* analysis coordinator during and after the commissioning runs. Tim Chupp has also agreed to serve as an Analysis Coordinator for the people not analyzing data at Los Alamos. Bear in mind that the amount of data is large. See Appendix A. We note that, the collaboration has analyzed and published measurements of PV asymmetries using the beam and apparatus.
"A current mode detector array for gamma-ray asymmetry measurements", M. Gericke *et al*., Nuclear Inst. and Methods in Physics Research, A, http://authors.elsevier.com/sd/article/S0168900204024313.

■ "P-Division should work with LANSCE division management and the experiment project management to generate an agreed upon plan detailing the steps that need to be taken for the installation and commissioning of the target as soon as possible during the 2005 run cycle. This plan should be submitted to DOE."

This activity is in progress. The management of the NPDGamma project has sent a memo to the division managements addressing the issue and proposing a solution, see Appendix B. The liquid hydrogen target completion plan will be first reviewed by the Hydrogen Target advisory team and the management and will then be submitted to DOE.

Scientific Program and Response

"The collaboration should make the best achievable measurement at LANSCE to learn as much as possible about the apparatus and obtain a first physics result"

This is the goal that has guided the development of the run plan.

Technical Status

See the hydrogen target discussion below.

Budget and Schedule

"The experiment has essentially expended the allocated DOE funds. An additional $220k is needed to complete the fabrication of the experiment which will be covered by internal LANL funding (LDRD)"

The agreed total budget of the NPDGamma construction project was given in The $n+p \rightarrow d+\gamma$ Project Management Plan for Experiment and Beam line Construction signed by the responsible parties on 2001. According to this plan, most of the funds for the project came from DOE, a significant portion came from NSF, and additional funds were provided by collaborating institutes. The biggest contribution came from the LANL internal funding sources (LDRD). The funding profile was structured so that the LANL

funding was used at the beginning of the project - to get the project started - then the DOE capital funds were used, and at the end of the project where some flexibility was required, LANL institutional funds were used again. Today, the project still has some of the LANL funds left for the target construction and commissioning. Up till now, we have not had any budget overrun.

Management and Commissioning Plans

"The continued efforts of collaborating institutes will be critical for the success of the experiment. The committee was concerned that the management team may not be speaking for the collaboration on issues of scheduling and the future of the experiment. The focus for some time appears to have been on moving the experiment to HIFR rather than exploiting the opportunities at LANSCE."

The rules of governance for the NPDGamma Collaboration are given in The $n+p \rightarrow d+\gamma$ Project Management Plan for Experiment and Beam line Construction signed by the responsible parties on 2001. The Spokesman and Project Manager act with the approval of the Executive Committee, which is elected by the collaboration members. The Executive Committee holds teleconferences as appropriate, typically every two weeks. The highest authority in the governance structure is decisions reached at a collaboration meeting.

The driving force for a move to a facility with a flux higher than at LANSCE is to measure the asymmetry with an error of 5×10^{-9}. It is not possible to make such a measurement at LANSCE, and it would be irresponsible not to consider other neutron sources. Indeed the Pendlebury committee, which first reviewed the proposal in 1997, recommended that the experiment be constructed in such a way that it could run at a reactor, and the Physics Division Advisory Committee also recommended moving the experiment to a reactor after it became apparent that the flux and beam availability at LANSCE precluded a sensitive measurement.

The interest in moving the experiment to HFIR developed because ORNL anticipated that a beam line would be available at HFIR and that ORNL could support the cost of installing the experiment on that beam line. After discussions in the Executive Committee and at a collaboration meeting, the Executive Committee wrote to DOE, NSF, and ORNL in late 2003 and requested that DOE consider moving the experiment to HFIR, after a run at LANSCE that would reach a sensitivity of 5×10^{-8}. The letter read, "After performing the initial measurement at LANSCE, we propose to move the experiment to the high flux reactor (HFIR) at ORNL." Jim Roberto, the Associate Director for Physical Sciences at ORNL, wrote to the collaboration and the sponsors approving NPDGamma to run at HFIR, and stated his belief that ORNL could support setting up the experiment at HFIR.

The move to HFIR was discussed for two hours at a collaboration meeting immediately preceding the DOE Review and a consensus was reached supporting presenting the idea to the review panel. The motivation for this decision was based on the collaboration's strong desire to achieve the main physics goals of the experiment as quickly as possible,

given that it would clearly not be practical to do so at LANSCE. Following the initial discussions with ORNL, the collaboration continued to move forward as effectively as possible at LANSCE while dedicating some additional effort to studying the anticipated beam properties at HFIR and coming up with an innovative new spin flipper design that would permit us to run with the reactor beam without a serious loss of polarization upon spin flip. As discussed in the original proposal, a pulsed beam offers significant advantages to the experiment provided that the flux is high enough to meet our statistics goals. The beam that will ultimately be available at the SNS is a very attractive option for NPDGamma. The Collaboration therefore welcomes the review panel's recommendation that the experiment consider moving to SNS and plans to propose such a move when the SNS calls for proposals in 2005.

"The project has lost a number of key players recently. No plan for how to replace these individuals was provided"

Of course, any long-term experiment must deal with the issues of personnel turnover and a change in the character of needed expertise through the project. Two students have obtained PhD theses from work on the project. The number of thesis students has now grown to three. We have recently lost two postdocs: a post doc package for hiring a new LANL postdoc has been submitted and two postdocs from UNH is now involved in NPDGamma. We have lost research scientists at Michigan and LANL. Most of this shortfall of effort has been taken up by expanded activity by other collaborators from Michigan, NIST, New Hampshire. The University of Tennessee and ORNL have joined the project. LANL is working towards hiring a new staff member to cover lost scientific personnel.

The shift coordinator, Bill Hersman reports that he has no difficulties in obtaining volunteers for experiment shifts for the ongoing data run at LANL in 2005. Among these volunteers are a former grad student and postdocs: this helps with continuity of effort and education of newer collaborators.

Reviewer Excerpts:

"Unfortunately the moderator brightness, proton current, and neutron guide transmission are all lower than originally estimated."

Not true for the neutron guide transmission. The collaboration measured and published an article on the moderator brightness. We commissioned the guide by measuring the flux and phase space of the beam out of the guide and compared with predictions based on the measured brightness [1]. The results were reported during the review in Bowman's overview talk slide 20 as well as Wilburn's report on the commissioning run, "We measured the neutron intensity and phase space out of the guide. The measured and predicted intensity and phase space (based on the guide specifications) agree to within the few % accuracy of the measurements." The three reasons for loss of sensitivity at

LANSCE are moderator brightness, proton current, and magnetic interference from Flight Path 11. The magnetic interference problem was extensively discussed in Bowman's over view talk, slides 13-15.

[1] “A measurement of the Flight Path 12 cold H2 moderator brightness at LANSCE”, Seo, P-N, Bowman, JD, Gericke, M., Greene, G., Long, J., Mitchell, GS, Penttila, SI, Wilburn, WS, Nuclear Instruments & Methods **A 517**, 285 (2004).

Liquid Hydrogen Target

“The completion of the target will require significant management oversight and collaboration participation to complete successfully. The panel recommended that Physics Division and LANSCE management play a stronger role in the development and implementation of the target completion plans.”

The Liquid Hydrogen Target is one of the 16 work packages of the NPDGamma construction project. Except of the Hydrogen Target the work packages are complete. In the Hydrogen Target work package responsibilities are shared so that Indiana is responsible for construction of the target and Los Alamos is responsible for infrastructure related to the facility and target safety. The target system was delivered to Los Alamos in 2003 where it was assembled and tested for cryogenics and safety. Problems were found that required major modifications. Most of new components have now been fabricated and testing continues in shed. After successful completion of the tests including run with hydrogen, the target system will be installed in the beam line in ER2.
Target has already gone through a number of safety reviews. The latest review was the target vent stack design that was reviewed on January 2005. The Hydrogen Target work package leadership has been changed so that the NPDGamma project manager, Penttila, assists the work package leader Snow. Also it should be mentioned that the other collaborating institutes have increased their contribution in the target effort. We are in a process to modify the target WBS structure so that it is stronger bound to the safety approval flow chart that was created with the Hydrogen Target Advisory Team.

APPENDIX A (This communication was sent to DOE on January 13, 2005)

Response to Recommendations of the DOE Review Committee
for the NPDGamma Experiment:

Jan. 12, 2005

The DOE review committee recommended that we appoint an analysis coordinator and an experiment coordinator. The Executive Committee has asked Greg Mitchell to serve as analysis coordinator and he has agreed to do so. Greg functioned as the *de facto* analysis coordinator during and after the commissioning run. Tim Chupp has also agreed to serve as an Analysis Coordinator for the people not analyzing data at Los Alamos and will arrange communications between the on-site and off-site workers. Bear in mind that the amount of data is large.

After some discussion, we decided to separate the functions of experiment coordinator as outlined below:

1. Run Plan Coordinator (RPC):
   The RPC will develop a run plan in consultation with subject matter experts. The Executive Committee will recommend improvements and endorse the run plan. David Bowman has agreed to serve as RPC.

2. Shift coordinator (SC):
   The SC will access the available manpower and coordinate shift schedules to optimize the use of personnel. Bill Hersman has agreed to serve as Shift Coordinator.

3. Experiment coordinators (EC):
   The EC will oversee activities during the run and take responsibility for the validity of the data taken. The EC will develop changes in the experimental program in response to events in collaboration with the RPC. The EC will oversee on and off line analysis to insure the validity of data taken.

The SC and EC will be rotating positions. Experiment Coordinators for different tasks are given in the table below.

NPDGamma Run Plan for the First Period of the 2005 Beam Cycle

This plan covers the first beam period from February 7, 2005, to the end of March 2005. The basic idea is that before beam is available we will get the apparatus ready, and then with beam we will first do system shake-down runs. The preparation of the apparatus and shakedown runs have a high priority -- see assumptions below. With lower priority, we will perform some measurements, including spin flipper efficiency measurements and measurements of parity violating asymmetries (PV) in nuclear targets. The LH_2 target work is being done now and will continue through the run; see the LH_2 target schedule

for details. The LH_2 target work has the highest priority regarding manpower, and it has a higher priority than any physics measurements using the beam. When the installation of the LH_2 target requires us to do so, we will stop running the experiments and start the LH_2 target installation work in the cave. When the target is in place, we need to pass safety reviews and then test the target system. Near the end of calendar year 05 we will have a few months of production runs.

The physics of the PV directional asymmetry of the total spectrum of gammas following capture on nuclei is interesting in its own right. The mean squared PV, A_γ, is dominated by parity mixing in the capture state, because the level spacing decreases exponentially with excitation energy. The typical gamma energy is 2 MeV, and therefore the daughter level has much smaller parity mixing than the capture level. The gamma transitions are either E1 or M1, and the E1 transitions are ~ 10 times faster than the M1 transitions. The total PV asymmetry is dominated by the gamma transitions with the largest energies. These transitions go from the capture state to the low-lying nuclear states. The average PV is proportional to an integral over excitation energy, E_x.

$$A_\gamma^2 = \varepsilon^2 16 \frac{\Gamma_{M1}}{\Gamma_{E1}} \int_0^{S_n} (S_n - E_x)^8 Exp\left(-2\sqrt{a E_x}\right) dE_x \Bigg/ \left(\int_0^{S_n} (S_n - E_x)^4 dE_x \right)^2$$

where: S_n is the neutron separation energy and a is the level-density parameter ($a \sim 8A$), Γ_{E1} and Γ_{M1} are the spreading widths of the E1 and M1 transition rates, and ε is the parity mixing in the capture state ($\varepsilon \sim \sqrt{\frac{\Gamma_W \rho(S_n)}{2\pi}}$ where $\rho(S_n)$ is the level density near the capture state and Γ_W is the spreading width of the weak interaction Evaluation of the full expression gives a RMS PV asymmetry in Aluminum of ~10^{-7}. The distribution of PV is non-Gaussian; there is a singular peak at PV = 0 and a broad distribution with a long tail.

We have already measured PV asymmetries with errors of a few 10^{-7} with the NPDGamma apparatus. Therefore, if we measure the Al asymmetry with improved precision, we might observe a statistically significant nonzero PV asymmetry. The measurement in Al is difficult because the capture cross section is small. Mike Dabaghian has identified about 20 nuclei with large capture cross sections. We should be able to measure PV in these nuclei to a few 10^{-8} in a few days each. By measuring PV in a number of nuclei with A ≤ 50, we can extend the TRIPLE measurement of the spreading width of the hadronic weak interaction below the measurement around A=100 done by TRIPLE. Such a series of measurements would lead to an interesting paper and perhaps a thesis for one of our students.

<u>Assumptions for the first half of the 2005 run plan:</u>

1. The LH_2 target is not ready, but we want to be in a position to get ready for data taking with the LH_2 target as quickly as possible; we will stop what we are doing to install the LH_2 target as soon as it is ready.
2. The detector motion is fixed and thoroughly tested.
3. The DAQ is ready and the algorithms used for the off-line 2004 data analysis are installed.
4. Most of the ^{6}Li shielding from ORNL has been installed.
5. The ^{3}He polarizer is tuned up and running.
6. The AFP system is working.
7. The rest of the apparatus ready

<u>When beam comes on we will carry out the following measurements in the order shown below:</u>

1. Measure the polarizer cell thickness and polarization.
2. Exercise U-D and L-R detector motion and analyze data.
3. Shielding studies.
4. Measure more PV asymmetries in In and Cu with the error of $5x10^{-7}$
5. Measure the analyzer cell thickness and polarization.
6. Measure the RFSF efficiency to an accuracy of 1%.
7. Measure PV in selected targets with large σ_γ with publishable accuracy.
8. Do more targets from point 7., in parallel with the LH_2 target installation work.

After step 4., we are in a position to measure PV in LH_2. Tasks 1. -4. can be completed in 4 weeks (allowing for 100% contingency).

Table 1. Run activities for the first run period, duration, and corresponding Shift and Run Coordinators:

Activity	Duration	Proposed shift coordinator	Proposed experiment coordinator
Measure polarizer cell thickness and polarization	1 week		David/Tom/Tim
Exercise U-D and L-R detector motion and analyze data	2 days		Greg/Seppo/…
Measure more PV in In and Cu	2 days		Michael/Greg
Measure analyzer cell thickness and polarization	1 week		Bill/Mikayel/Hongguo
Measure RFSF efficiency	1 week		Pil/Scott/David
Shielding studies	3 days		Rob/Seppo
Measure PV in selected targets with large σ_γ	2 weeks		Mikayel/Bill/Mike S./David
Do more targets from 7 in parallel with the LH_2 target installation work	n weeks		Mikayel/Bill/Mike Seppo/David

Schedule for the NPDGamma LH_2 Target

Dec-21-2004

Status of the LH_2 target effort

The LH_2 target system is under testing in the shed. Several cool downs without cryogenics have been performed and some problems have been identified in the cold part of the target. The new components are under fabrication in machine shops. We had a 10% design review of the ER2 and shed vent stack and gas handling system ventilation systems. The draft report has been sent to us, and we are working on a response to the findings. The draft of the vent stack review report is attached to this status report. The detailed design of the components of the ER2 vent stack that will be outside ER2 is completed, and the date for the review of the design drawings is set to be Dec-22-04. We have initiated the fabrication and also installation procurements.

Plan for the LH_2 target effort:

The following is a list of the major milestones for the target:

Target testing in shed:

1.	Assemble the modified cryogenic part of the target	Jan-28-05
2.	Testing of target without cryogenics	Feb-25-05
3.	Installation of vent line and herculate tent	Feb-25-05
4.	IWD's approved for cryogenic operation in shed	Feb-25-05
5.	Readiness review by extended safety committee	Mar-11-05
6.	IWD approved for H_2 operation in shed	Mar-24-05
7.	Testing of the target with hydrogen	Apr-29-05
8.	Target testing in shed completed	Apr-29-05

Target installation and testing in ER2:

1.	Fabrication of outside part of vent stack	Jan-21-05
2.	Installation of outside part of the vent stack	Jan-28-05
3.	Detail design of piping inside ER2	Feb-25-05
4.	Fabrication of piping inside ER2	Mar-24-05
5.	Installation of vent lines inside ER2	Apr-29-05
6.	H_2 supply line constructed	Apr-29-05
7.	Design of new gas handling system	Mar-31-05
8.	Construction of new gas handling system	Apr-29-05
9.	Start installation of target in cave	May-02-05
10.	Target ready in cave	May-31-05
11.	IWD's approved	Jun-10-05
12.	Testing of target in cave without H_2	Jun-30-05
13.	Readiness review by extended safety committee	Jun-30-05
14.	IWD for H_2 operation in ER2	Jun-30-05
15.	Target tested with LH_2	Jul-29-05
16.	Target ready for the beam testing	Aug-01-05

APPENDIX B
(this memo was submitted to the P- and LANSCE management in March 2005)

On October 6-8, 2004 DOE Office of Nuclear Physics held the annual technical progress review of the LANL n+p->d+γ Experiment.

In mid March we received the review report where among other comments there were statements regarding the completion of the liquid hydrogen target and a strongly worded request for a stronger role of P- and LANSCE Division management.

Here are few quotes from the report concerning this issue:

P-Division should work with LANSCE division management and the experiment project management to generate an agreed upon plan detailing the steps that need to be taken for the installation and commissioning of the target as soon as possible during the 2005 run cycle. This plan should be submitted to DOE.

It will be a real loss to physics if LANSCE and P division don't work together to make this experiment happen in the next 12 months. We think they understand the urgency of the situation, but the community will need to see concrete results very soon, not just talk, to really be convinced that the situation is under control.

… All work components of the experiment project have been completed with the exception of the installation and commissioning of the liquid hydrogen target, which has substantial safety hurdles to overcome. This could seriously compromise the ability of the collaboration to complete a first physics measurement during the 2005 beam cycle. The proposed schedule to install and operate the LH_2 target in the beam line has zero float and was presented as an "optimistic" schedule. The completion of the target will require significant management oversight and collaboration participation to complete successfully. The panel recommended that Physics Division and LANSCE management play a stronger role in the development and implementation of the target completion plans.

There are several other comments in the text of the DOE Review that urge LANSCE and P Division involvement in preparing the Liquid Hydrogen target for the 2005 run at LANSCE.

The NPDGamma collaboration has to response to these statements and comments in a week or so, by 4-10-05. In the response the collaboration will present a plan for the installation and commissioning schedule of the LH_2 target. According to DOE, a plan should be agreed to by the P and LANSCE management and P and LANSCE management should be involved in the plan and work to facilitate the implementation of the plan.

To produce the agreeable plan and having a stronger communication between the management of the two divisions – this should be in place already since both of the divisions have steaks here - more formal and functional organization is required.

Our proposal is that the existing "Hydrogen Target advisory team" chaired by Knudson that has been in place for about one year and which has advised the NPDGamma Collaboration in the target effort, will be given a more formal status, a clear charge, and the membership should be endorsed and confirmed by the both divisions.

To the present main body of the team (Knudson/chair, Nelson, Kelley, Penttila, Long, also participated by Lataille, Etuk, Sondheim, Teasdale) should be re-enforced with deputy group leaders from P-23/Lisa Garner, Gus Sinnis and P-25/Scott Wilburn, this would cover P-division management. The team has already from LANSCE Area Manager Ron Nelson/LANSCE-12, Knudson/LANSCE-6 and Pat Kelley/LANSCE-6(?) and Josh Long/LANSCE-3.

The charge for the team could be – (there is no priority in the list):

- Provide technical support for the NPDGamma liquid hydrogen target project
- Define the safety envelope and oversight the safety of the liquid hydrogen target
- Report to P and LANCSE management
- Organize and perform design and safety reviews of the hydrogen target
- Oversight progress of the hydrogen target project

The charge should come from the P- and LANSCE division management.

All of us who try to accomplish something on floor know that it is very hard to be productive at Lab. nowadays. There are many new formalities of operation and safety requirements. Getting formal approval is often difficult because the process to get approval is not well defined and (for understandable reasons) the people who have to give the approvals are risk averse. We cannot meet the milestones of the target project that were approved before the Lab. stand down. To complete successfully the liquid hydrogen target part of the NPDGamma project we need to create a new set of milestones that consider the new lab environment. For the ultimate success we need all possible support from the management of the both divisions during execution. It is important for us that we show to outside world and to our funding agencies – DOE, NSF, other institutes - that we are open for business. All components of the NPDGamma apparatus and beam line were demonstrated to perform at a level that will allow us to measure the NPDGamma asymmetry with an error of 5 10^-8 before the shut down. Completion of the LH_2 target and thus the NPDGamma project at LANSCE will demonstrate that the Lab. and LANSCE, and Physics Divisions are functioning.